Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

PHYTOPHTHORA AVOCADO ROOT ROT

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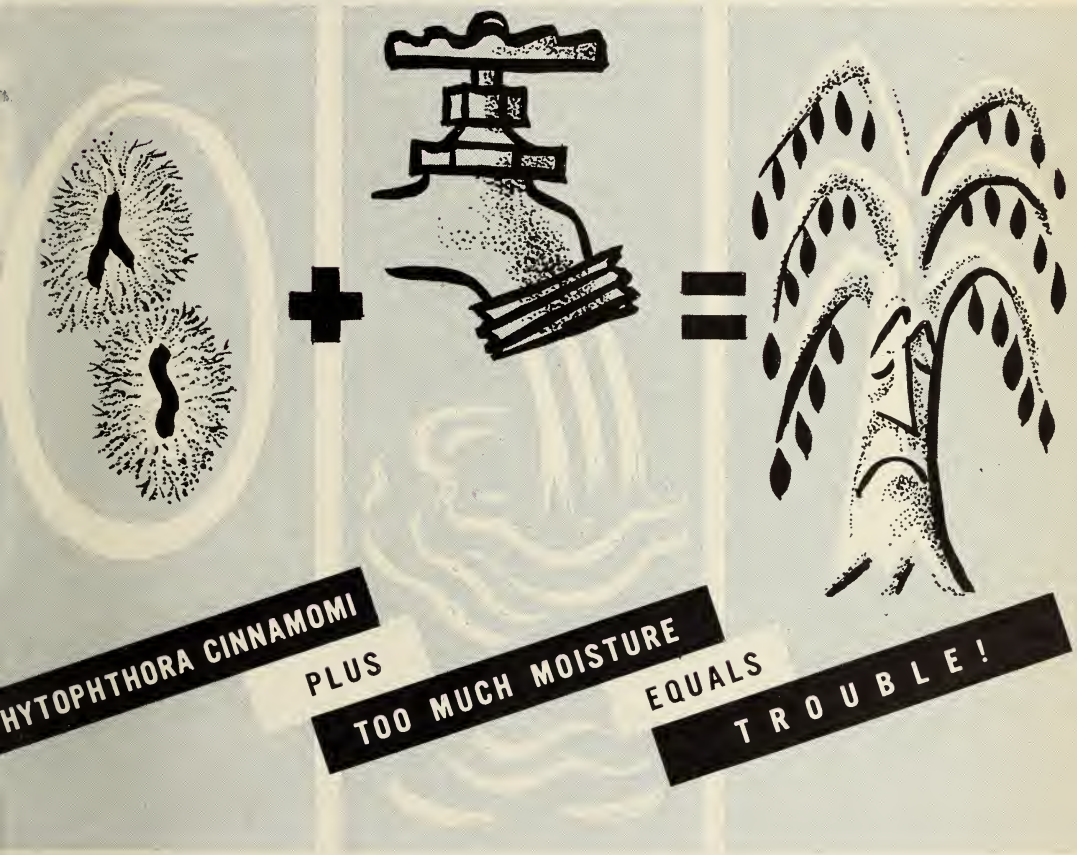

CALIFORNIA AGRICULTURAL
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CIRCULAR 465

AVOCADO ROOT ROT . . .

is a disease caused by a soil fungus, Phytophthora cinnamomi, known commonly as the cinnamon fungus or the avocado root rot fungus. This soil organism was first found invading cinnamon trees, thus its name. It is now known to attack many kinds of plants and is the most serious disease affecting avocado trees in many parts of the world. It has affected an estimated 4000 acres of avocados in California, and is found in Santa Barbara, Ventura, Los Angeles, Orange, Riverside, and San Diego counties.

This circular tells how to recognize the disease and outlines what is known to date about control measures that will lessen the effect of the disease, prolong the life of infected trees, prevent spread of the trouble.

Research in this field is far from complete and it is hoped that more specific recommendations can be made at a later date.

IT HITS YOUNG TREES . . . like the one shown in the photo at the left.

THE AUTHORS:

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The two elements required for development of the disease in an avocado planting are the fungus, and periods of excess soil moisture. Root rot does not develop when one of these factors is absent. Soil moisture conditions favorable for fungus activity commonly result from poor drainage. Drainage may be poor because the surface soil is underlain with an impervious layer or because the entire soil profile contains considerable clay.

How to recognize the disease

Leaves of infected trees are smaller than normal, usually pale green instead of dark green, often wilted, and tend to drop, giving the tree a sparse appearance. New growth is often absent; if new leaves are formed they do not develop normally and are of pale green color. Branches tend to die back in advanced stages of disease; fruit is small. Trees of any size, from nursery trees to large, old trees, may be affected.

Many of the small feeder roots on diseased trees are blackened, brittle, and dead. In advanced stages of disease it is difficult to find feeder roots when digging under affected trees. The soil under affected trees tends to stay wet, as small absorbing roots are not taking up water.

The fungus

The avocado root rot fungus is known as a water mold because it thrives in wet places. It is a minute form of plant life which needs wet soil for the best development of its three spore or seedlike stages:

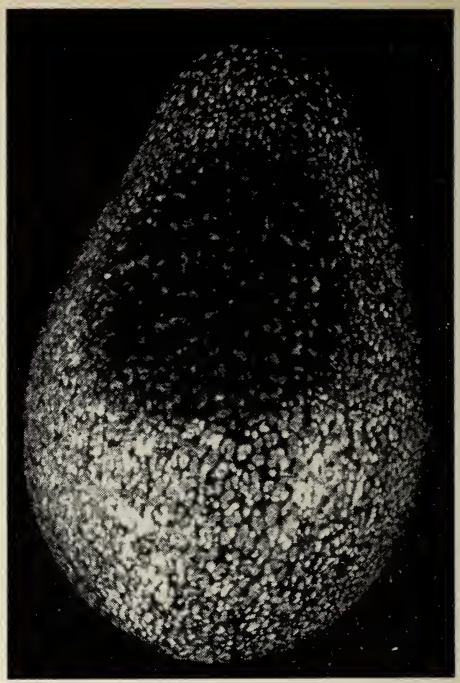
Sporangia, which liberate swimming spores (zoospores)
Resistant spores (oospores)
Chlamydospores.

AND BEARING TREES . . . as pictured in the photo below.

These spore types are invisible to the naked eye. To give an idea of their minute size, approximately ten million zoospores could be placed in an area one inch square. The fungus requires water for formation and liberation of its spores, and for germination and infection. The spore-forming bodies are formed at relatively high soil temperatures, mainly between 77° and 82° F. This indicates that the major infection takes place in the warmer months of the year. The fungus makes no growth below 50° F nor above 90° F. The fungus can build up very rapidly because sporangia are produced in great abundance in the soil and each sporangium forms a large number of swimming spores.

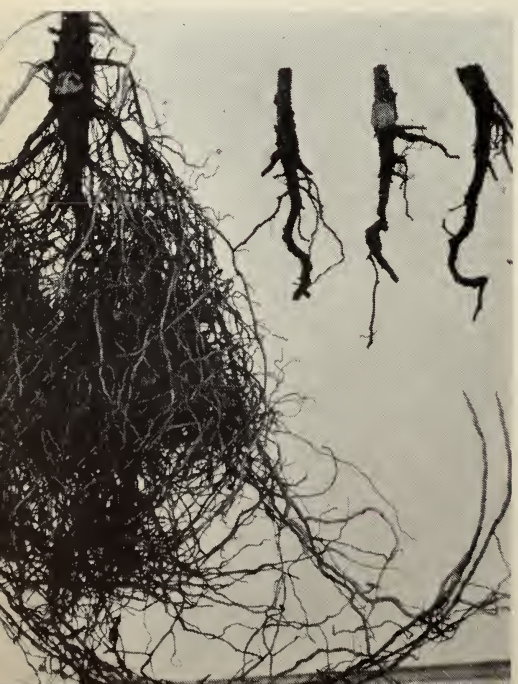
How to identify the fungus

For positive identification of the fungus it is necessary to make laboratory cultures of small feeder roots on cornmeal agar. In many cases the fungus may be present on healthy-appearing trees on the margin of diseased areas, and its presence can only be detected by taking root and soil samples and making laboratory cultures. Several commercial laboratories are available for making these tests for interested avocado growers. Contact your University of California Farm Advisor office for information on where tests may be made.



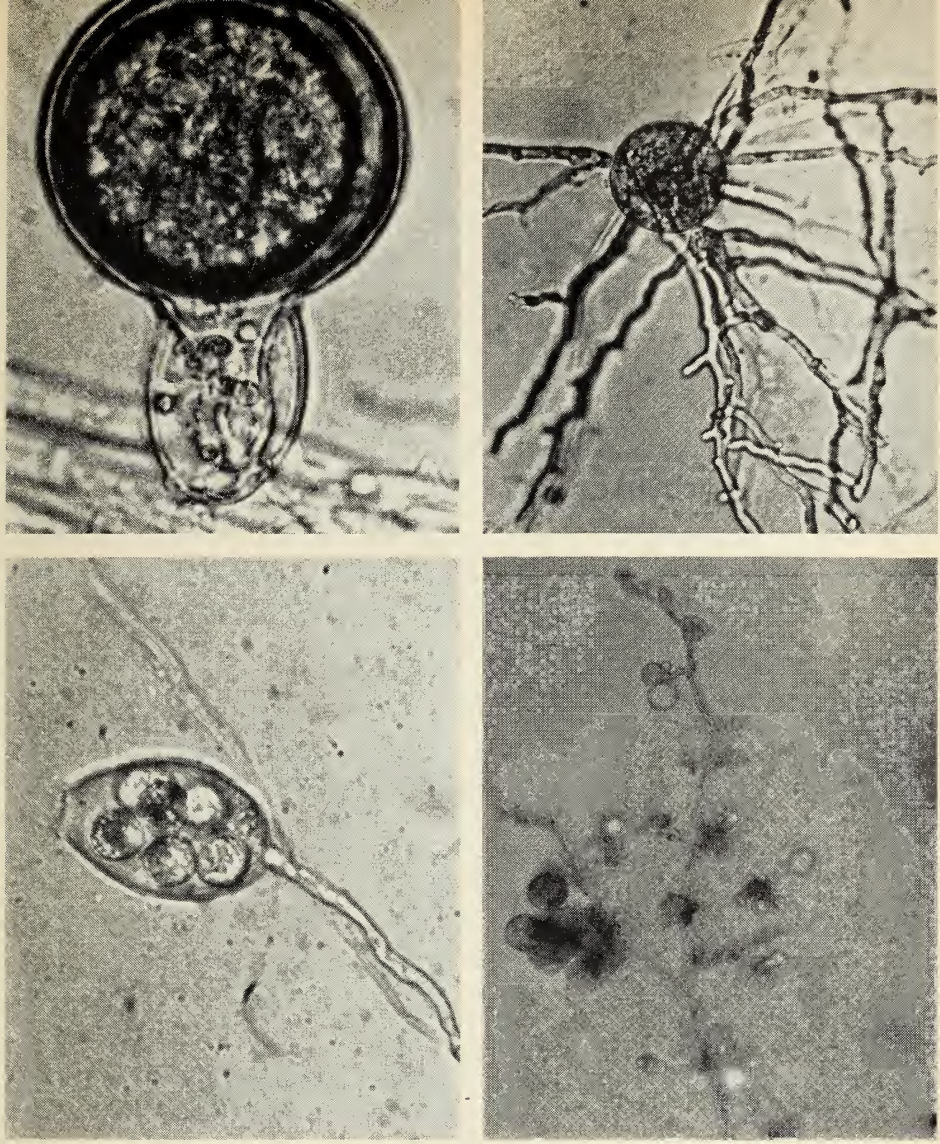
IT INVADES THE FRUIT and seed as well as the tree, as shown by the dark spot on the avocado fruit above.

ROOT GROWTH IS INHIBITED . . . the root system at the left developed from a seedling grown in steam-sterilized soil, the three on the right in soil infested with Phytophthora cinnamomi.



In sampling a suspected tree, take several cupfuls of soil from three or four locations around the tree. Mix these samples from one tree together and take out 2 to 3 cupfuls for sending to a laboratory. Samples should include soil and small feeder roots taken from a moist part of the root zone and from a depth of zero to six inches. Place samples in small polyethylene bags to prevent drying out before cultures are made and send immediately to a laboratory for diagnosis.

It must be remembered that positive detection of this soil fungus is difficult, especially where the infestation is light.



MICROSCOPE'S-EYE VIEW OF SPORE STAGES of the fungus. Upper left: resistant spore (oospore); upper right: germinating chlamydospore. Lower left: sporangium containing several zoospores; lower right: vegetative stage of fungus with some chlamydospores. These spores are enlarged from 200 to 1260 times.

In such cases, a laboratory test in which the root rot fungus is not recovered is not positive assurance that none is present.

Host list of the fungus

In addition to the avocado, the fungus also attacks a wide variety of other plants. These plants could serve as sources of infection for the avocado grove. For example, if a grower should bring a camellia affected with *P. cinnamomi* onto his property, the fungus could spread from the diseased camellia and start a new case of root rot in his avocado grove. The following is a list of plants which the fungus, *P. cinnamomi*, is known to attack:

Common Name	Scientific Name
Coniferous Trees	
Arborvitae	*Thuja* sp.
Arborvitae, Parsons	*Thuja occidentalis compacta*
Cedar, Atlas	*Cedrus atlantica*
Cypress	*Cupressus* sp.
Cypress, Italian	*Cupressus sempervirens*
Cypress, Lawson	*Chamaecyparis lawsoniana*
Deodar cedar	*Cedrus deodara*
Douglas fir	*Pseudotsuga taxifolia*
Fir, Nordmann	*Abies nordmanniana*
Fir, Siberian	*Abies sibirica*
Fir, Silver	*Abies pectinata*
Incense cedar	*Libocedrus decurrens*
Juniper	*Juniperus* sp.
Larch, European	*Larix decidua*
Larch, Japanese	*Larix leptolepis*
Pine	*Pinus* sp.
Pine, Canary	*Pinus canariensis*
Pine, Loblolly	*Pinus taeda*
Pine, Monterey	*Pinus radiata*
Pine, red	*Pinus resinosa*
Pine, Scotch	*Pinus sylvestris*
Pine, shortleaf	*Pinus echinata*
Spruce, Colorado	*Picea pungens*
Spruce, Norway	*Picea abies*
Yew	*Taxus* sp.
Yew, Anglojap	*Taxus media*
Yew, Irish	*Taxus baccata* var. *fastigiata*
Yew, English	*Taxus baccata*
Yew, Japanese	*Taxus cuspidata*
Evergreen Broadleafed Trees	
Avocado	*Persea americana*
Aguacate, Chinini	*Persea schiedeana*
Cinnamon, Malay	*Cinnamomum burmanni*
Eucalyptus	*Eucalyptus* spp.
Ocotea	*Ocotea architectorum*
Olive	*Olea* sp.
Papaya	*Carica papaya*
Quinine	*Cinchona officinalis (C. ledgeriana)*
	Cinchona pubescens (C. succirubra)
Tanoak	*Lithocarpus densiflorus*
Tung oil tree	*Aleurites fordii*
Deciduous Broadleafed Trees	
Beech	*Fagus* sp.
Birch, paper	*Betula papyrifera*
Chestnut	*Castanea margaretta* var. *arcuata*
Chestnut, American	*Castanea dentata*
Chestnut, Chinese	*Castanea mollissima*
Chestnut, European	*Castanea sativa*
Chestnut, Japanese	*Castanea crenata*
Chestnut	*Castanea* sp.
Chinkapin, Alabama	*Castanea alabamensis*
Chinkapin, Allegheny	*Castanea pumila*
Chinkapin, Ashe	*Castanea ashei*
Chinkapin, Henry	*Castanea henryi*
Chinkapin, Ozark	*Castanea ozarkensis*
Chinkapin, Trailing	*Castanea alnifolia*
Jacaranda	*Jacaranda* sp.
Locust, Black	*Robinia pseudoacacia*

Common Name	Scientific Name
Oak	*Quercus* sp.
Oak, Chestnut	*Quercus montana*
Oak, Cork	*Quercus suber*
Oak, English	*Quercus robur*
Oak, red	*Quercus borealis*
Oak, White	*Quercus alba*
Peach	*Prunus persica*
Plane, Oriental	*Platanus orientalis*
Plum	*Prunus* sp. (Mariana and Myrobolan rootstocks)
Pomegranate	*Punica* sp.
Walnut, black	*Juglans nigra*
Walnut, Persian	*Juglans regia*

Shrubs, Perennials, Annuals

Australia heath	*Epacris microphylla*
Australia heath	*Epacris pulchella*
Azalea	*Rhododendron* sp.
Azalea	*Rhododendron japonicum*
Broad bean	*Vicia faba*
Butterfly flower	*Schizanthus* sp.
Camellia	*Camellia* sp.
	Camellia japonica
	Camellia japonica var. *magnoliaeflora*
	Camellia sasanqua
Castorbean	*Ricinus communis*
Calceolaria	*Calceolaria* sp.
Chilean firebush	*Embothrium coccineum*
Cineraria	*Senecio* sp.
Eriostemon	*Eriostemon crowei*
Geraldton wax-flower	*Chamaelaucium uncinatum*
Heather	*Erica hyemalis*
	Erica nivalis
	Erica regerminans
	Erica willmoreana
Holly, Japanese	*Ilex crenata*
Lily, Philippine	*Lilium philippinense*
Mexican clover	*Richardia scabra*
Micrantheum	*Micrantheum ericoides*
Myrtle, compact	*Myrtus communis* var. *compacta*
Nicotiana	*Nicotiana glutinosa*
Pineapple	*Ananas comosus* var. *sativus*
Pultenaea	*Pultenaea elliptica*
Rhododendron	*Rhododendron* sp.
	Rhododendron californicum
	Rhododendron carolinianum
	Rhodendron catawbiense
	Rhododendron caucasicum var. *Boule de Niege*
	Rhododendron indicum
	Rhododendron maximum
	Rhododendron mucronulatum
	Rhododendron ponticum
Snapdragon	*Antirrhinum majus*
Spanish broom	*Spartium junceum*
Stock	*Matthiola* sp.
Viburnum	*Viburnum* sp.
	Baeckea brevifolia
	Dillwynia ericifolia
	Leucopogon microphyllus
	Phyllota phylocoides
	Sprengelia incarnata

YOU CAN PREVENT INTRODUCTION AND SPREAD OF THE FUNGUS

The cinnamon fungus can be introduced or spread to new areas by movement of infested soil; movement of water carrying spores; infected nursery stock or seed. Here are some precautions to take to avoid such situations.

Use clean seed

The fungus can be spread in avocado seed if the fruit from which the seed is taken is allowed to remain for several days on ground infested with the fungus. Ideally, all seed used for planting should be taken from fruit picked from the tree. Where this is not possible seed should be carefully inspected for light brown, discolored areas. Suspicious looking seed should be discarded. To be certain of freedom from fungus infection in seed taken from the ground, heat the seed by immersing in a hot water bath at 120°–125° F for 30 minutes. The thermometer should be accurate, as temperatures over 130° F will damage the seed.

The principle behind the use of moist heat for killing disease organisms is that the plant can stand more heat than can the organism. Hot-water treatment is inexpensive, does an excellent job of eradicating internally borne pathogens, and requires only a simple procedure. A 100–200 gallon tank for treatment is desirable because of greater ease of temperature control, but a sink or tub is adequate. A circulating pump or a wooden paddle should be used to agitate the water bath. A trickle of steam or water 20°–25° F above that of the treatment is used to keep the temperature within the range required.

Porous cloth bags or wire screen containers may be used to hold the seeds during immersion. They should not be filled more than ⅔ full or the water circulation will be restricted. Introduction of too many seeds at one time into a small tank will lower the water temperature excessively. After the required time of 30 minutes the seeds should be removed, immersed in or sprayed with clean, cold water, and spread out to dry on a clean surface not in contact with the ground.

THE FUNGUS SPREADS FROM OTHER PLANTS . . . the plants on the right were inoculated with isolates of the fungus taken from chestnut, heather, avocado, pine, and quinine trees respectively. The healthy plant on the left was not inoculated.

Use clean nursery stock

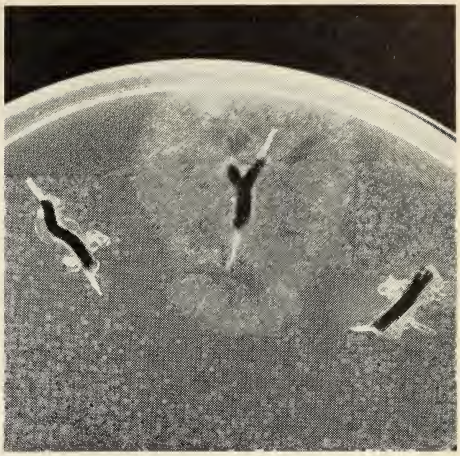
Diseased nursery stock has undoubtedly been the primary means by which the fungus has been so widely distributed over the avocado-producing areas of southern California. A soil fungus of this type can be readily transported with balled, or container grown plants. Severely wilted trees are, of course, discarded in the nursery. Less obviously diseased trees, and those with the fungus present in the soil but with no obvious symptoms, undoubtedly are sold, as the cinnamon fungus may be in the soil and cause no noticeable trouble if soil moisture is not excessive.

To avoid spreading the disease by this means the grower should insist on healthy, vigorous nursery stock grown by a reliable nurseryman in fumigated, or steamed soil, or in the case of field-grown trees, from a nursery site that does not favor disease development. Nurseries should not be planted on old avocado soil or areas that tend to stay wet, or are poorly drained, or on areas adjacent to groves with root rot.

Use equal care in selecting ornamental plants for planting on avocado property. As emphasized above *P. cinnamomi* attacks many other woody plants in addition to the avocado, and could be carried onto a property in infected stock.

For trees or other plants grown in containers, soil fumigation or steaming will insure soil free of Phytophthora. Methyl bromide is an effective fumigant when used under a plastic cover at a dosage of 3 pounds per 100 cubic feet of soil for 24 hours. Steaming soil to 180° F from ½ to 1 hour is also effective in killing the fungus.

Container-grown material, particularly with open bottoms such as tarpaper pots, should be grown on clean benches so that any possible infection from the soil will be avoided. It would be useless to treat seed and soil and then place plants on soil infested with the root rot fungus.



LABORATORY ISOLATION . . . here are three small avocado roots with the fungus growing on agar culture from the one in the center.

Nurserymen in particular should be very careful to avoid bringing *P. cinnamomi* onto their property or into their propagating area by any of the means mentioned here.

The only way to be absolutely certain that nursery stock does not carry the root rot fungus is to heat treat the seed, and grow plants in steamed or fumigated soil in containers which have no contact with infested soil. Another means to prevent introduction of the root rot fungus in the planting stock is to plant heat-treated seed directly in the field.

Prevent movement of soil or water from infested areas

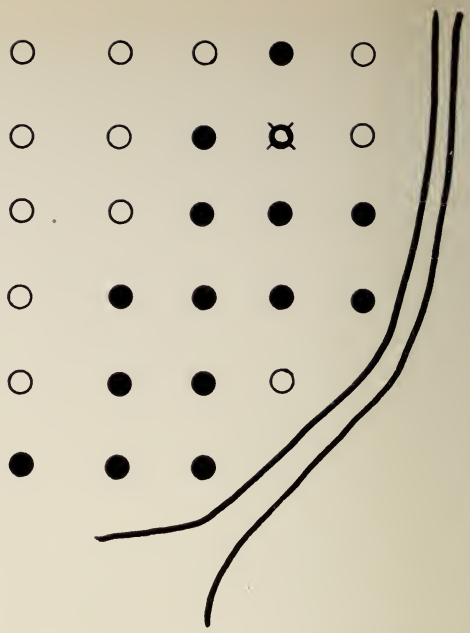
Take all possible steps to prevent movement of soil or water from diseased areas into noninfested groves. The fungus can be moved by any means by which moist soil is moved—on cultivation equipment, trucks, cars, shovels, soil augers, shoes. The fungus has been recovered from mud scraped from shoes following walking over an area of infested soil.

Small pieces of equipment, such as shovels, augers, trowels, should be washed well after being used around diseased trees, wiped or dipped in alcohol

or formaldehyde solution. A 70 per cent solution of methanol, ethanol, or rubbing alcohol can be used. Commercial formalin or formaldehyde should be diluted to make a 5 per cent solution. Cultivation equipment should be used in the healthy portion of the grove before being used in the diseased portion, then washed and allowed to dry thoroughly after use in the diseased section.

The fungus also can be spread downhill from an area of infection by surface drainage water, because the swimming spores are readily moved in water. Watertight drains should be installed to take care of surface run-off if a diseased area lies above a healthy grove. If gophers are active in a grove their runs may serve as good avenues of movement of the fungus, particularly its movement downhill in water. This is another good reason for gopher control.

Where possible, cooperative arrangements should be made with any neighboring avocado growers so that drainage from your own diseased trees does not run over into healthy acreage owned by someone else.



THE FUNGUS SPREADS . . . primarily downhill from one diseased tree (with cross). The black spots in this diagram of an orchard indicate new infections occurring on downhill slope within four years after original infection.

STEAM-STERILIZING HELPS . . . The soil in which these plants were grown was taken from under diseased trees. That in the two cans on the right was steam-sterilized.

Plant on well-drained soil

A final, and exceedingly important point to remember in connection with the prevention of avocado root rot is that there is *much less chance of damage from the root rot fungus if avocados are planted on well-drained soil.* This means that the entire soil profile must be well-drained, not merely the surface soil. Drainage may be retarded by the presence of an impervious layer, by a change in soil structure, or by an underlying barrier such as plow sole.

Future plantings should not be made in soils that drain slowly and are sure to cause trouble if the root rot fungus is present or is brought in.

Once root rot is definitely identified in a grove, these measures are suggested:

Small spots of infection

(Up to 6 trees)

Map the area and have cultures made from roots of healthy trees bordering the affected diseased trees, to determine just how much area has been invaded by the fungus.

Isolate the diseased area by putting up a temporary fence; permit no traffic of equipment, dogs, farm animals, or people across the area. This is particularly important during periods when soil is wet and might be moved to healthy portions of the grove.

If the area is not too extensive (up to 6 trees) cut the trees back to a short stump and fumigate the soil to reduce or eliminate the fungus population. The fungus is not usually present in the aboveground parts of the tree, hence disposal of the debris presents no problem in the spread of the fungus in most cases. Very rarely the fungus causes cankers on the trunk, sometimes to a height of 3 or 4 feet, with accompanying oozing and production of white deposits of sugar. If cankers are present the trunk should be burned. There is danger if trees are pulled that the fungus will be spread to healthy portions of the grove if roots and attached soil are hauled through the grove.

On the basis of recent research involving many field plots, it is known that

DRYING THE SOIL HELPS . . . all four pots above contained infested soil. Those on the left received no treatment; in those on the right the soil was dried to one per cent moisture before replanting avocado seedlings.

the fungus population can be greatly reduced and possibly eliminated if heavy dosages of fumigants are used. This is most applicable and has the most chance of success if treatment is done as soon as possible after the disease appears in a grove—when only a few trees are affected. These high dosages will kill the trees, but this is necessary if the fungus is to be eliminated or greatly reduced in population.

Complete elimination of a fungus from soil, once it has become well established and spread over a wide area, is exceedingly difficult. Fumigation, coupled with other measures such as drying the soil by withholding irrigation water and replanting later with resistant crops may serve to eliminate the fungus from the grove. On the basis of results to date it cannot be stated whether or not it will pay a grower to treat an extensive area of diseased trees.

What are the best chemicals?

On the basis of present information, the most effective materials for attempting to eliminate the fungus are Vapam, D-D, Telone. Methyl bromide has proven successful in light, sandy soils but has not been effective in heavy soils.

Vapam. Use 1 quart of Vapam 4-S per 100 sq. ft. of soil surface in 4 gallons of water per square foot, or followed by 4 gallons of water per square foot. This is about 6 acre inches of water.

The Vapam treatment can be applied by (1) injection into sprinkler lines, (2) by using Prizer fertilizer injectors, (3) with a proportioner on a hose, (4) or by sprinkling on the soil.

Sprinklers should be arranged inside of and around the margins of the area to be treated so that complete and uniform coverage is obtained. If the soil is level, Vapam can also be applied in basins, using the same amount of material and water.

If methods 3 or 4 are used, a split application is suggested. Apply 1 pint of Vapam per 100 sq. ft. followed by 2 gallons of water per sq. ft., then apply the second pint of Vapam followed by 2 more gallons of water per sq. ft.

More information is available for Vapam than for the other chemicals. Based on a large number of field plots, this material is giving good results in apparently eliminating the fungus on plots up to 2 years old, and involving several types of soil.

D-D or Telone. Inject this into soil at the rate of 150 gallons per acre, using a weed gun. Make injections 6 to 12 inches deep and spaced 12 inches apart. To obtain a dosage of D-D of 150 gallons per acre, approximately 13 cc (slightly less than ½ ounce of the liquid) should

VAPAM IS EFFECTIVE . . . all six pots below contain heavily infested soil. The three on the left were treated with Vapam before planting; the others were not.

be injected in each of the holes. Telone, a new material, contains more active chemical than D-D, thus it may be possible to use less material and obtain the same results.

Methyl bromide has appeared effective to date only on light, sandy-loam soils. Use 3 lbs. per 100 sq. ft. of soil surface. This material must be injected under a plastic tarpaulin; it is a gas, usually supplied in one-pound cans under pressure. Cans are opened with a special opener with a plastic or rubber tubing attached. The gas is injected under the tarpaulin covering the area to be treated. Better results are obtained if the material is heated during application by releasing it through a copper coil placed in hot water. The edges of the tarpaulin must be sealed by covering with dirt. Methyl bromide is an extremely poisonous gas and should be handled with great care; follow directions on the labels of the cans or cylinders containing the gas.

What does material cost?

To treat an entire acre with the amounts mentioned above, the materials would cost approximately as follows: Vapam—$325; D-D—$210; Telone—$240; and methyl bromide—$975. These chemicals are obviously expensive on an acre basis, but would be practical for attempting to eliminate the fungus from small areas of infection.

Large areas of infection

(Over 6 trees)

If an extensive area (more than 6 trees) is involved, there are several possibilities for combating the disease:

Barriers

Establish a barrier to prevent spread of the fungus through soil and along roots. To have any possibility of success with barriers it is first necessary to map the area and have laboratory cultures made to determine the extent of invasion of the fungus. It may be present on trees

A BARRIER MAY STOP SPREAD . . . but it is necessary to go beyond the diseased area (black dots). Presence of fungus on surrounding healthy trees can only be detected by laboratory cultures. Some of the diseased trees may not yet show top symptoms.

that are apparently healthy. The barrier should then be established one tree row beyond where the fungus occurs. If an attempt is not made to limit the spread of the fungus by some type of barrier, the infested area will increase in size each year.

Information on barriers is in the preliminary stages but three types are suggested:

Ditch. Dig a ditch well into the impervious layer in the subsoil. In many groves with root rot, either clay or granite is encountered at depths of 18 to 30 inches. Ditch-digging machines have been used for this purpose in San Diego County.

Chemical. Treat an area 8 to 10 feet wide around the infested area with Vapam at the rate of 1 quart per 100 sq. ft., and 4 gallons of water per sq. ft. Repeat every 6 to 12 months. Other chemicals may be useful in this respect, and are under investigation.

Dry barrier. Let a row of trees on the edge of the infested area remove water from the soil during one irrigation season; *do not irrigate this row nor the diseased area.* If possible, water the sur-

rounding healthy trees only on the side away from the diseased trees. Maintain this as a permanent dry zone; trees in the dry zone can be removed as they die or are no longer removing water from the soil. Even though the dry barrier will be wet by winter rains, drying during the irrigation season will greatly retard the progress of the fungus. The fungus population is greatly reduced or even eliminated when soil moisture is extremely low.

In establishing chemical or dry barriers, if the diseased trees are above a healthy section of the grove diversion drains should be established to prevent movement of the fungus in surface water from infested to healthy areas—either yours or your neighbor's.

Treat diseased trees

Alfalfa meal has the property of retarding the activity of the root rot fungus in some soils for reasons which are not yet understood. It should be applied at the rate of 100 to 150 lbs. per tree around trees in *early stages of disease*, or healthy trees bordering infected areas. Under such circumstances it has prolonged the life and productivity of treated trees for several years. The material must be incorporated into the top few inches of the soil underneath the tree, extending out to the drip line of the outer branches. Alfalfa straw has not been effective in tests to date, nor have other types of organic matter including bean straw, manure, sawdust, soybean, and cottonseed meals.

FOR SOME REASON . . . alfalfa meal helps to combat the disease. All four cans above contained soil from under diseased trees. The plants on the left received no treatment; those on the right were planted in the same soil mixed with alfalfa meal at the rate of five tons per acre.

Careful irrigation can help to retard the progress of the disease and prolong the life of the affected trees because of the close association of the development of the disease with excess soil moisture. Water use is markedly reduced in trees affected with root rot, because of the destruction of the small feeder roots. Hence, if all trees in a grove, healthy and diseased alike, are given the same amount of water in one irrigation, water will accumulate in the soil around the diseased trees and accentuate the disease situation. In controlled experiments, trees given twice as much water in the presence of the root rot fungus developed root rot more rapidly and severely than trees given the lesser amount of water.

Therefore any practice that tends to reduce the period that free water may remain in the soil will reduce severity of the disease even though it does not eliminate it. Such practices include: selection of a site with good drainage; careful irrigation to prevent watering soil that is already wet; and drainage to take care of runoff of winter rainfall. Tensiometers are useful for determining moisture conditions in the soil.

If reservoirs are used, run-off water from an infested area should not be repumped, as the fungus could easily be carried to other parts of the grove in this re-cycled irrigation water.

Fungicides. An extensive testing program in laboratory, greenhouse, and field has been underway for several years, with the aim of developing a fungicide that could be applied to diseased trees and would control the disease. Ideally this is

a good approach to disease control; practically, no tree disease has yet been controlled by this method.

Laboratory and field experiments have shown that applying low dosages of the organic fungicides Vapam and nabam (Dithane D-14, or Parzate liquid) in the irrigation water to living trees will result in reduction in population of the root rot fungus in the soil. The tree response has not reflected the reduction in *P. cinnamomi* in the soil, however. Following treatment with dosages of these chemicals which the tree will tolerate, the fungus has usually increased rapidly in the soil until it has reached its original level within 6 to 8 weeks after treating. Vapam in particular is highly toxic to avocado roots as well as to the fungus and must be used with care around living trees. Under hot weather conditions, application of a solution of ½ pint of Vapam in 4 gallons of water per sq. ft. (approximately 50 ppm) has severely damaged large avocado trees.

This approach has definite possibilities and is worth further investigation, particularly in the case of a disease of the importance of avocado root rot. Experimental work along this line is being accelerated.

Replant with resistant crops

Plants which are resistant to *Phytophthora cinnamomi* include all types of citrus, macadamia nut, cherimoya, persimmon. Natural infection by the fungus has not been reported on annual flower crops and vegetables.

If healthy avocado trees adjoin the replant area, do not irrigate the diseased trees through one irrigation season. This will help to dry the soil and reduce the fungus population. Then remove diseased trees and replant the area with resistant crops. The grower should combine this control measure with one of the barrier treatments noted above.

What about resistant rootstocks?

The method of control that has the greatest possibility of success in the long run is the development of a rootstock that is resistant to *Phytophthora cinnamomi.* High resistance has been discovered in Latin American selections, but these small-fruited, resistant types are not compatible with commercial avocado varieties.

Appreciable resistance has been found in the Duke variety. Some seedlings from Duke trees have at least moderate resistance; continued selections are being made from these seedlings in an attempt to find higher resistance. Current selections are much more resistant than any of the usual commercial rootstocks that have been tested.

An expanded collecting and testing program is being continued along several lines, with emphasis on large-seeded varieties. Hybridization is also an important phase of the program. It should be realized that developing a practical, compatible resistant rootstock is a long-term project.

IN SHORT . . .

You can PREVENT Avocado Root Rot by

- using clean seed
- using clean nursery stock
- planting in clean soil
- keeping your soil well drained
- preventing movement of water, soil, or plants from infested areas into clean areas

You can COMBAT Avocado Root Rot

(In small areas—to 6 trees)

- map the area to determine fungus distribution
- isloate the area
- fumigate the soil

(In large areas—over 6 trees)

- establish barriers—isolate area
- irrigate carefully
- experimental treatments—alfalfa meal
- replant with resistant crop

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